

Denne rapport
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L&U DOK. SENTER

L. NR. 30284030001

KODE well 31/2-5 nr 13

Returneres etter bruk

RESERVOIR FLUID STUDY

for

A/S Norske Shell Exploration and Production

Well: 31/2-5

North Sea, Norway.

Ikke Vannanalyse

CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

20

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Well: 31/2-5

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CORE LABORATORIES UK LTD.
Petroleum Reservoir Engineering
ABERDEEN, SCOTLAND

17 March 1981

A/S Norske Shell Exploration & Production
Damlse Ferusuei 43
P.O. Box 10
40-33 Forus
Norway

Subject: Reservoir Fluid Study
Well: 31/2-5
North Sea, Norway
Our File Number:
RFLA 81028

Attention: Mr. Dave Jolly.

Gentlemen,

On the 28th January 1981 an RFT sample from the subject well was received in our Aberdeen laboratory for transfer and subsequent analysis. The results of these analyses as requested are presented in the following report.

On receipt in the laboratory the chamber was heat treated at 160°F for twenty-four hours prior to transfer in single phase. Two 650cc samples were transferred and the remainder of the sample drained. The recovery details may be found on page fourteen.

A portion of the reservoir fluid was placed in a high pressure visual cell and thermally expanded to the requested operating temperature of 160°F. During a constant composition expansion at this temperature the fluid exhibited a bubble point of 2133 psig. As requested this bubble point was raised to 2280 psig by the addition of gas from a second RFT chamber. The remaining portion of the reservoir fluid was treated in the same manner, thus providing sufficient reservoir fluid to perform the requested analysis.

The hydrocarbon composition of the reservoir fluid through hexanes was then determined by low temperature fractional distillation. This composition in terms of both mol and weight percent is presented on page two.

A portion of the reservoir fluid was placed in a high pressure visual cell and thermally expanded to the operating temperature of 160°F. During a constant composition expansion at this temperature, a bubble point pressure of 2280 psig was observed. The results of the pressure-volume relations may be found on page three.

A large volume of reservoir fluid was subjected to a differential vaporization at the reservoir temperature of 160°F resulting in the liberation of a total of 405 standard cubic feet of gas per barrel of residual oil with an associated relative oil volume of 1.198 barrels of saturated oil per barrel of residual oil. At several pressure levels below the observed saturation pressure, oil density, gas deviation factor and gas hydrocarbon composition were monitored. These data are tabulated on pages five through seven and graphically represented on pages eight and nine.

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- 2 -

Whilst maintaining reservoir temperature, the viscosity of the liquid phase was measured in a rolling ball viscosimeter through a wide range of pressures from above saturation pressure to atmospheric pressure. These data show a minimum of 1.32 centipoise at saturation pressure. The remaining viscosity data are presented on page ten.

At conditions stipulated by A/S Norske Shell Exploration and Production, a series of flash separations were performed at laboratory temperature. The factors and data derived from these tests may be found on page twelve.

At each primary stage of separation, the gas evolved was collected and analysed for hydrocarbon composition. These compositions are presented on page thirteen.

A supplementary report containing the extended compositional analysis will be issued shortly.

It has been a pleasure to be of service to A/S Norske Shell Exploration and Production. Should any questions arise concerning data presented in this report, or if we can be of further assistance, please do not hesitate to contact us.

Yours very truly

Core Laboratories UK Limited
Reservoir Fluid Analysis



Les K. Sebborn
Laboratory Manager

LKS/STB
15cc/Addressee

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Page 1 of 14

File RFLA 81028

Company A/S Norske Shell Expl. & Prod. Date Sampled _____

Well 31/2-5 State North Sea

Field _____ Country Norway

FORMATION CHARACTERISTICS

Formation Name	_____
Date First Well Completed	_____, 19__
Original Reservoir Pressure	_____ PSIG @ _____ Ft.
Original Produced Gas-Oil Ratio	_____ SCF/Bbl
Production Ratio	_____ Bbl/Day
Separator Pressure and Temperature	_____ PSIG _____ °F.
Oil Gravity at 60°F.	_____ °API
Datum	_____ Ft. Subsea
Original Gas Cap	_____

WELL CHARACTERISTICS

Elevation	_____	Ft.
Total Depth	_____	Ft.
Producing Interval	_____	Ft.
Tubing Size and Depth	_____ In. to _____	Ft.
Productivity Index	_____ Bbl/D/PSI @ _____	Bbl/Day
Last Reservoir Pressure	2280	PSIG @ _____ Ft.
Date	_____, 19__	
Reservoir Temperature	160	°F. @ _____ Ft.
Status of Well	_____	
Pressure Gauge	_____	
Normal Production Rate	_____	Bbl/Day
Gas-Oil Ratio	_____	SCF/Bbl
Separator Pressure and Temperature	_____ PSIG, _____	°F.
Base Pressure	_____	PSIA
Well Making Water	_____	% Cut

SAMPLING CONDITIONS

Sampled at	_____	Ft.
Status of Well	_____	
Gas-Oil Ratio	_____	SCF/Bbl
Separator Pressure and Temperature	_____ PSIG, _____	°F.
Tubing Pressure	_____	PSIG
Casing Pressure	_____	PSIG
Sampled by	_____	
Type Sampler	_____	

REMARKS:

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Page 2 of 14

File RFLA 81028

Company A/S Norske Shell Expl. & Prod. Formation

Well 31/2-5 County North Sea

Field State United Kingdom

HYDROCARBON ANALYSIS OF RESERVOIR FLUID SAMPLE*

COMPONENT	MOL PERCENT	WEIGHT PERCENT	DENSITY	API	MOL WEIGHT
Hydrogen Sulfide	NIL	NIL			
Carbon Dioxide	0.81	0.25			
Nitrogen	0.72	0.14			
Methane	35.27	3.97			
Ethane	4.00	0.84			
Propane	1.34	0.41			
iso-Butane	1.14	0.47			
n-Butane	0.47	0.19			
iso-Pentane	0.54	0.27			
n-Pentane	0.24	0.12			
Hexanes	1.15	0.69			
Heptanes plus	54.32	92.65	0.8869	27.9	243
	<u>100.00</u>	<u>100.00</u>			

*Cylinder Number 80397.

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Page 3 of 14

File RFLA 81028

Well 31/2-5

VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

1. Saturation pressure (bubble-point pressure) 2280 PSIG @ 160 °F.
2. Specific volume at saturation pressure: ft³/lb 0.02031 @ 160 °F.
3. Compressibility of saturated oil @ reservoir temperature: Vol/Vol/PSI:
From 5000 PSIG to 4000 PSIG = 6.76x10⁻⁶
From 4000 PSIG to 3000 PSIG = 7.38x10⁻⁶
From 3000 PSIG to 2500 PSIG = 7.88x10⁻⁶
From 2500 PSIG to 2280 PSIG = 8.21x10⁻⁶

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Page 4 of 14

File RFLA 81028

Well 31/2-5

PRESSURE-VOLUME RELATIONS AT 160°F.

<u>Pressure</u> PSIG	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
5000	0.9803	
4000	0.9869	
3000	0.9943	
2700	0.9966	
2600	0.9974	
2500	0.9982	
2400	0.9990	
2300	0.9998	
<u>2280</u> Saturation Pressure	1.0000	
2214	1.0074	3.991
2152	1.0151	3.922
2077	1.0249	3.871
1940	1.0461	3.770
1777	1.0767	3.661
1644	1.1077	3.559
1502	1.1492	3.438
1339	1.2090	3.325
1173	1.2921	3.190
1015	1.3993	3.076
887	1.5248	2.943
758	1.6922	2.845
641	1.9016	2.771
490	2.3406	2.644
369	2.9507	2.551
263	2.9992	2.419

(1) Relative Volume: V/V_{sat} is barrels at indicated pressure per barrel at saturation pressure.

(2)
$$Y \text{ Function} = \frac{(P_{sat} - P)}{(P_{abs}) (V/V_{sat} - 1)}$$

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Page 5 of 14

File RFLA 81028

Well 31/2-5

DIFFERENTIAL VAPORIZATION AT 160 °F.

Pressure PSIG	Solution Gas/Oil Ratio(1)	Relative Oil Volume(2)	Relative Total Volume(3)	Oil Density gm/cc	Deviation Factor Z	Gas Formation Volume Factor(4)	Incremental Gas Gravity
2280	405	1.198	1.198	0.7887			
2200	392	1.193	1.209	0.7907	0.861	0.00683	0.612
1900	342	1.178	1.267	0.7962	0.862	0.00791	0.612
1600	292	1.161	1.351	0.8021	0.872	0.00948	0.615
1300	241	1.142	1.488	0.8082	0.887	0.01185	0.619
1000	190	1.125	1.726	0.8144	0.907	0.01569	0.625
700	139	1.107	2.189	0.8209	0.930	0.02284	0.636
400	88	1.090	3.377	0.8270	0.957	0.04050	0.664
250	62	1.080	5.011	0.8313	0.971	0.06435	0.701
110	33	1.068	10.256	0.8357	0.987	0.13868	0.806
0	0	1.043		0.8461			1.294

At 60°F = 1.000

Gravity of Residual Oil = 28.6 API at 60°F.

- (1) Cubic feet of gas at 14.73 psia and 60°F. per barrel of residual oil at 60°F.
- (2) Barrels of oil at indicated pressure and temperature per barrel of residual oil at 60°F.
- (3) Barrels of oil plus liberated gas at indicated pressure and temperature per barrel of residual oil at 60°F.
- (4) Cubic feet of gas at indicated pressure and temperature per cubic foot at 14.73 psia and 60°F.

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DIFFERENTIAL VAPORIZATION AT 160°F.

Hydrocarbon Analyses of Produced Gases - Mol Per Cent

Pressure PSIG.

Component	2200	1900	1600	1300	1000	700	400	250	110	0*
Carbon Dioxide	1.17	1.23	1.29	1.39	1.53	1.77	2.14	2.40	2.72	3.05
Nitrogen	1.96	1.53	1.19	0.89	0.64	0.42	0.22	0.14	0.07	0.04
Methane	91.82	91.91	91.70	91.32	90.66	89.41	85.98	81.64	69.79	26.90
Ethane	3.59	3.81	4.20	4.65	5.20	6.03	8.31	11.13	18.30	30.75
Propane	0.70	0.74	0.80	0.87	0.98	1.18	1.69	2.26	3.95	17.57
iso-Butane	0.33	0.33	0.34	0.36	0.40	0.49	0.69	1.00	2.17	9.94
n-Butane	0.10	0.10	0.10	0.11	0.12	0.14	0.20	0.29	0.66	3.32
iso-Pentane	0.11	0.11	0.12	0.12	0.13	0.14	0.19	0.27	0.60	3.36
n-Pentane	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.05	0.12	0.55
Hexanes	0.07	0.08	0.09	0.11	0.14	0.18	0.26	0.37	0.76	2.08
Heptanes Plus	0.13	0.14	0.15	0.16	0.18	0.22	0.29	0.45	0.86	2.44
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>

Calculated Gas Gravity (Air = 1.000) 0.612 0.612 0.615 0.619 0.625 0.636 0.664 0.701 0.806 1.294

Calculated Gross Heating Value - BTU per cubic foot of dry gas at 14.73 and 60°F. 1041 1048 1056 1064 1075 1090 1127 1179 1336 2087

*Gas evolved between 110 psig and 0 psig.

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Page 7 of 14

File RFLA 81028

Well 31/2-5

G.P.M. VALUES FOR PRODUCED GASES.

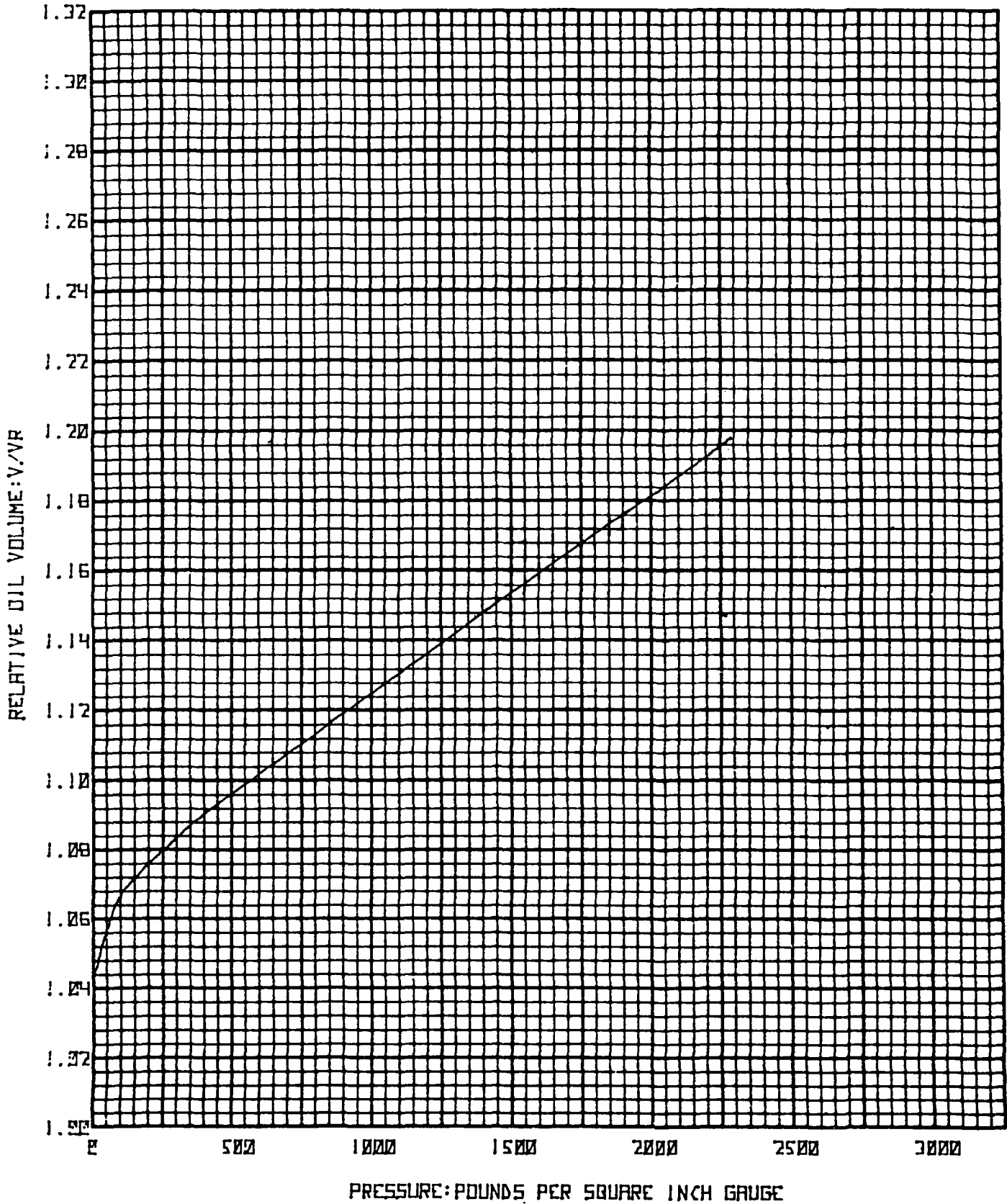
Pressure : Psig.

	2200	1900	1600	1300	1000	700	400	250	110	0
Propane	0.193	0.204	0.220	0.239	0.270	0.325	0.465	0.622	1.087	4.834
iso-Butane	0.108	0.108	0.111	0.118	0.131	0.160	0.226	0.327	0.710	3.250
n-Butane	0.032	0.032	0.032	0.035	0.038	0.044	0.063	0.091	0.208	1.046
iso-Pentane	0.040	0.040	0.044	0.044	0.048	0.051	0.070	0.099	0.220	1.229
n-Pentane	0.007	0.007	0.007	0.007	0.007	0.007	0.011	0.018	0.044	0.199
Hexanes	0.029	0.033	0.037	0.045	0.057	0.074	0.106	0.151	0.310	0.848
Heptanes Plus	0.059	0.064	0.068	0.073	0.082	0.100	0.132	0.204	0.390	1.108
	<u>0.468</u>	<u>0.488</u>	<u>0.519</u>	<u>0.561</u>	<u>0.633</u>	<u>0.761</u>	<u>1.073</u>	<u>1.512</u>	<u>2.969</u>	<u>12.514</u>

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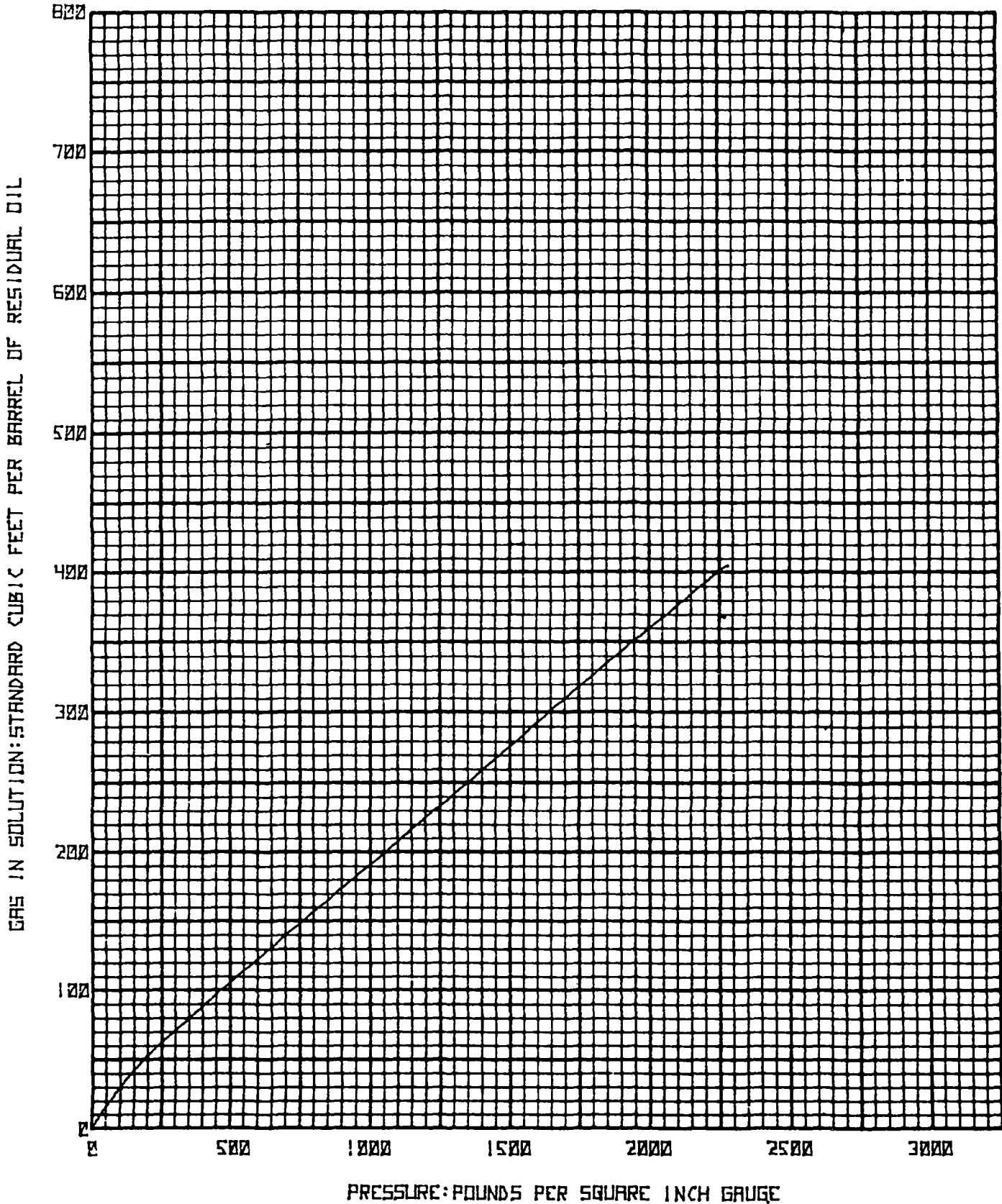
DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 160° F.

Company R/S NORSE SHELL Formation _____
Well 31/2-5 County NORTH SEA
Field _____ State NORWAY



DIFFERENTIAL VAPORIZATION OF RESERVOIR FLUID AT 160° F.

Company A/S NORSE SHELL Formation _____
Well 31/2-5 County NORTH SEA
Field _____ State NORWAY



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Page 10 of 14

File RFLA 81028

Well 31/2-5

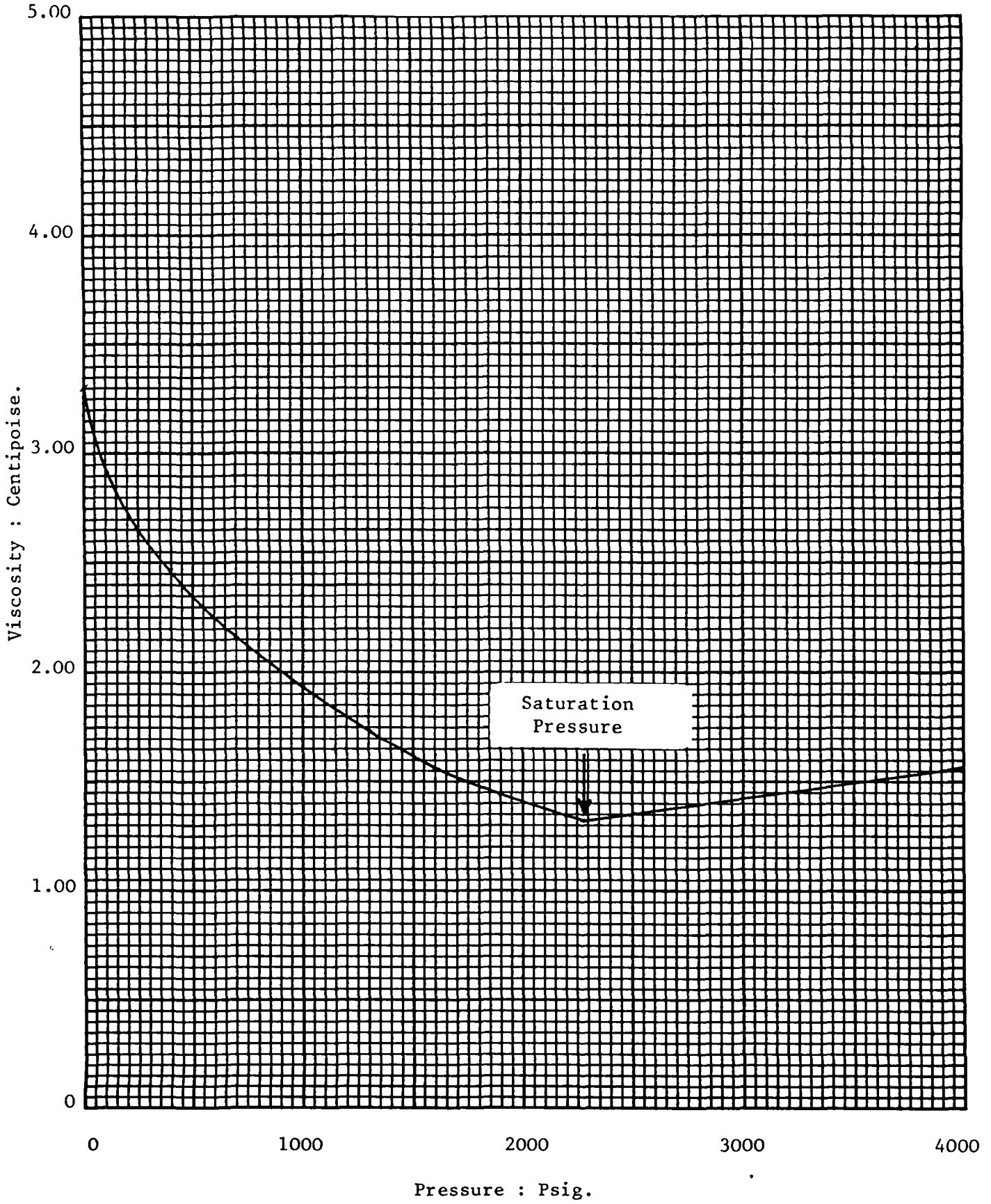
VISCOSITY DATA AT 160 °F.

<u>Pressure PSIG</u>	<u>Oil Viscosity Centipoise</u>	<u>Calculated Gas Viscosity Centipoise</u>	<u>Oil/Gas Viscosity Ratio</u>
5000	1.70		
4000	1.56		
3000	1.42		
2500	1.35		
<u>2280</u>	Saturation		
Pressure	1.32		
2200	1.34	0.0173	77.46
1900	1.44	0.0164	87.80
1600	1.56	0.0156	100.00
1300	1.74	0.0148	117.57
1000	1.94	0.0141	137.59
700	2.16	0.0135	160.00
400	2.46	0.0129	190.70
250	2.66	0.0125	233.60
110	2.92	0.0119	245.38
0	3.33		

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Viscosity of Reservoir Fluid at 160°F.

Company A/S Norske Shell Expl. & Prod. Formation _____
Well 31/2-5 County North Sea
Field _____ State Norway



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Page 12 of 14

File RFLA 81028

Well 31/2-5

SEPARATOR TESTS OF RESERVOIR FLUID SAMPLE

Separator Pressure PSI Gauge	Separator Temperature °F.	Gas/Oil Ratio (1)	Gas/Oil Ratio (2)	Stock Tank Gravity °API @ 60°F.	Formation Volume Factor(3)	Separator Volume Factor(4)	Specific Gravity of Flashed Gas
450 to 0	68	244	254			1.041	0.611*
	68	113	114	28.8	1.186	1.003	0.794
250 to 0	68	284	291			1.025	0.620*
	68	69	69	29.0	1.180	1.003	0.824
150 to 0	68	312	317			1.016	0.631*
	68	44	44	29.0	1.180	1.003	0.847
50 to 0	68	344	347			1.008	0.661*
	68	16	16	28.9	1.183	1.003	+

* Gas collected and analysed for hydrocarbon composition.

+ Insufficient gas for analysis.

- (1) Gas/Oil Ratio in cubic feet of gas at 14.73 psia and 60°F. per barrel of oil at indicated pressure and temperature.
- (2) Gas/Oil Ratio in cubic feet of gas at 14.73 psia and 60°F. per barrel of stock tank oil at 60°F.
- (3) Formation Volume Factor is barrels of saturated oil at 2280 psig and 160°F. per barrel of stock tank oil at 60°F.
- (4) Separator Volume Factor is barrels of oil at indicated pressure and temperature per barrel of stock tank oil at 60°F.

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Page 13 of 14

File RFIA 81028

Well 31/2-5

HYDROCARBON ANALYSES OF SEPARATOR GAS SAMPLES

Separator Conditions: 450 PSIG @ 68 °F. 250 PSIG @ 68 °F. 150 PSIG @ 68 °F. 50 PSIG @ 68 °F.

<u>Component</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>	<u>Mol Percent</u>	<u>GPM</u>
Hydrogen Sulfide	NIL		NIL		NIL		NIL	
Carbon Dioxide	1.66		1.52		1.62		2.05	
Nitrogen	0.96		0.92		0.85		0.73	
Methane	91.45		90.19		88.81		85.31	
Ethane	4.80		5.77		6.65		8.50	
Propane	0.71	0.195	1.00	0.275	1.28	0.352	2.00	0.550
iso-Butane	0.24	0.079	0.34	0.111	0.45	0.147	0.81	0.265
n-Butane	0.06	0.019	0.09	0.028	0.12	0.038	0.22	0.069
iso-Pentane	0.05	0.018	0.07	0.026	0.09	0.033	0.17	0.062
n-Pentane	0.01	0.004	0.01	0.004	0.02	0.007	0.03	0.011
Hexanes	0.03	0.012	0.04	0.016	0.05	0.020	0.08	0.033
Heptanes plus	0.03	0.014	0.05	0.023	0.06	0.027	0.10	0.045
	<u>100.00</u>	<u>0.341</u>	<u>100.00</u>	<u>0.483</u>	<u>100.00</u>	<u>0.624</u>	<u>100.00</u>	<u>1.035</u>

Calculated gas gravity(Air=1.000):0.611

0.620 0.631 0.661

Calculated gross heating value
(BTU per cubic foot of dry gas
at 14.73 psia and 60°F.):

1044 1063 1078 1116

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Page 14 of 14

File RFLA 81028

Well 31/2-5

RFT RECOVERY DATA.

Opening pressure of chamber 1100 psig at 68°F.

The chamber was heated to 160°F and stabilized at 5000 psig prior to transfer. Two 650cc samples were transferred in single phase to Core Laboratories sample cylinders numbers 80357 and 80412. The remaining contents were then pumped off from the chamber resulting in the following recoveries:-

Oil	1.64	litres of 30.6° API.
Water	180	ccs
Gas	99.29	standard litres (gas gravity 0.635)

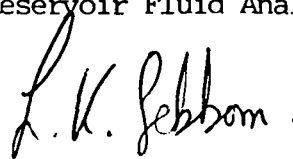
Calculated gas-oil ratio 340 scf/stock tank bbl.

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A/S NORSKE SHELL EXPLORATION & PRODUCTION
Well: 31/2-5

RFLA: 81028

Core Laboratories UK Limited
Reservoir Fluid Analysis

A handwritten signature in black ink, appearing to read "L. K. Sebborn". The signature is written in a cursive style with a large initial 'L'.

Les K. Sebborn
Laboratory Manager-RFL